

THE RECONSTRUCTION OF THE  
TYMPANA  
OF ST. SOPHIA AT ISTANBUL

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## INTRODUCTION

THE known contemporary records give only tantalizing glimpses of the progress of the initial construction of Justinian's church and of subsequent structural changes prior to the mid-nineteenth century. The diversity of interpretation which these records will bear has already been amply demonstrated by scholars, particularly in their attempts to establish the original forms of the great north and south tympana.<sup>1</sup> A major obstacle to the writing of a definitive structural history has been the inaccessibility of most of the working masonry behind marble revetments, mosaics, and painted stucco. Lacks of bond, changes in the character of the masonry, and similar features which would otherwise furnish independent evidence of probable structural changes are thus largely hidden from view, and the great size of the building would alone preclude a general stripping merely in search of such indications. Further less direct indications are, however, provided by the distortions—tilts of columns and piers, spreads and bows of arches and vaults—produced progressively throughout the building by the large and changing forces acting on all principal elements. Given an adequate knowledge of the forces that would act at successive stages for different sequences of construction and of the distortions that would be likely to result, it is, in principle, possible to establish the actual sequence simply from a correlation of precise measures of the actual present distortions. The texts may then be used to fix in time certain points in the sequence. Unfortunately the present distortions can be inferred from the present forms only by first making assumptions about the manners in which these forms were initially set out. The only internal test of the validity of these assumptions is their reasonableness (in terms of what is known about the practices of the time) and their self-consistency coupled with the reasonableness and self-consistency of the conclusions drawn. It is necessary finally, therefore, to fall back on the more direct evidence of the masonry itself, of other related constructional features, and of the surface decoration. Since the evidence can now be sought much more purposefully to test specific conclusions, it becomes possible to substitute very limited and more practicable tests for the much more extensive exploration that would otherwise be called for.

A comprehensive study, on these lines, of the sequences of construction and subsequent reconstruction and of the associated principal structural actions throughout the building was begun in 1964. It was made possible by Mr.

<sup>1</sup> See, for instance, William R. Lethaby and Harold Swainson, *The church of Sancta Sophia, Constantinople* (London, 1894); Eugenios M. Antoniades, *Ekphrasis tes Hagias Sophias* (Athens, 1907–09); Cornelius Gurlitt, *Die Baukunst Konstantinopels* (Berlin, 1907–13); Emerson H. Swift, *Hagia Sophia* (New York, 1940); Kenneth J. Conant, "The First Dome of Haghia Sophia and its rebuilding," *The Bulletin of the Byzantine Institute*, I (1946), 71–78; and Panagiotis A. Michelis, "L'esthétique d'Haghia-Sophia," *Corsi di cultura sull'arte ravennate e bizantina* (Ravenna, March–April 1963), 207–76.

Robert Van Nice's precise measurements and delineation of the building as it is today and by his intimate knowledge of all aspects of its construction, and it has been undertaken in close collaboration with Mr. Van Nice and with his invaluable assistance in taking additional measurements where necessary. Since the tympana and their supporting arcades are only infilling screens set between the main piers and the main north and south arches, they were not a major focus of attention. They are, nevertheless, of great importance architecturally. It was therefore considered worthwhile in 1966 to make a very limited test to confirm the conclusion then reached that they must have been entirely reconstructed at a date well after the completion of the initial construction. The failure of this test to disclose the limits of the reconstruction—while seeming to leave no doubt that it must have taken place—led to further tests being made in 1967 and 1968. These not only disclosed the limits at all points where they were sought, but shed considerable further light on the probable date of the reconstruction and the probable original form of the tympana. Together with tests made on some elements of the main structure, they also provided the fullest confirmation of the validity of the initial approach to the interpretation of the precise geometry of the present forms.

This paper concentrates on the tests and on the conclusions drawn from them. In presenting this account of them it is a great pleasure to acknowledge Mr. Van Nice's assistance and to thank the Turkish authorities for permitting the tests to be made. We are especially grateful to Bay Feridun Dirimtekin, Director of the Ayasofya Museum, for his unfailing cooperation and sympathetic interest. I also wish to thank Mr. Van Nice for preparing the drawings from which the folding plate and figure 1 have been reproduced.

#### PREVIOUS INVESTIGATIONS

For the present purpose it seems unnecessary to review the long history of scholarly speculation about the tympana prior to the discussion by Underwood and Hawkins<sup>2</sup> of the dates of the ornamental mosaics alongside the portrait of the Emperor Alexander (fig. 1). In seeking a date for the later (phase 2) mosaic, they were led to suggest that the entire tympana plus the supporting gallery arcades were reconstructed at some time after completion of the original (phase 1) mosaic. It then appeared that this reconstruction was probably part of that known to have taken place immediately after the first collapse of the dome in 558, though there is no reference to the tympana in the fairly detailed account of that reconstruction left by Agathias.<sup>3</sup>

The principal evidence on which this suggestion was based came from a close study of the mosaic itself and of other related details. It was noted that the original mosaic had been replaced by that of phase 2 in all the soffits of the arcades carrying the tympana, although it survived almost intact in all

<sup>2</sup> Paul A. Underwood and Ernest J. W. Hawkins, "The Mosaics of Hagia Sophia at Istanbul: The Portrait of the Emperor Alexander," *Dumbarton Oaks Papers*, 15 (1961), 189–217, esp. 210–15.

<sup>3</sup> *Historiae*, bk. V, *Patrologia Graeca*, 88, cols. 1556C–1557A.

the corresponding soffits of the exedrae arcades; that the mosaics of the two phases alongside the Alexander portrait were differently related to the marble revetment and *opus sectile* panels on the south face of the pier and arcade and to the tie bar across the first arch of the arcade; and that the seemingly original *opus sectile* panels were a poor fit to the spandrels of the present arches.

Supporting evidence was found in three observations relating to the present alignments and forms of the tympana and arcades. The first was the setting back of all the columns of the arcades well behind the original setting marks incised in their stylobates. The second was the relative straightness of the upper cornices immediately above the arcades as compared with the more pronounced inward bends (toward the nave) of the lower cornices. The third was the greater verticality of the outer faces of both tympana above the gallery roof as compared with the pronounced outward leans of their inner faces. To the first of these observations could be added two related facts: most of the columns are almost vertical in contrast to the backward leans of the main piers which terminate the arcades, and they stand in almost straight lines although the original setting marks follow the inward bends of the lower cornices.

#### CONCLUSIONS FROM THE PRESENT FORMS

Some of these characteristics of the tympana and arcades are illustrated in more detail in relation to the surrounding structure in figure 3.<sup>4</sup> The outward leans of the main piers commence well below gallery level but increase there about threefold to about 3 cm. for every 1 m. rise. Above the upper cornice two arches at each side carry the pendentives and the dome. The lower arches (referred to here as the main arches) span only the clear distance between the piers and are the full width of the piers, excluding the added width of the projections from which the great east and west arches spring. Above the gallery roof they are prominently revealed on the exterior. Since, however, the tympana are constructed with their inner faces continuous with those of the arches, they show today on the interior only as discolorations in the stucco which betray the pattern of the underlying brickwork, as shown more clearly in Salzenberg's partly conjectural engraving reproduced in figure 4.<sup>5</sup> The upper arches span the considerably greater distance between the projections from the piers just referred to and, like the east and west arches, directly carry the pendentives. Their outer faces are now hidden within the dome base so that their width is indeterminate, but their soffits are partly revealed on the interior.

<sup>4</sup> This figure is taken from plate 4 of Robert L. Van Nice, *Saint Sophia in Istanbul: An Architectural Survey*, Installment 1 (Dumbarton Oaks, Washington, D.C., 1966). Other relevant details may be found on pls. 5, 18, 22, 25, and 27.

<sup>5</sup> From W. Salzenberg, *Alt-christliche Baudenkmäler von Constantinopel vom V. bis XII. Jahrhundert...* (Berlin, 1854), 21. Apart from its failure to show the joins between the original structure and the reconstruction and to represent more faithfully the major cracks and the precise geometry of the present forms, the chief faults of that part of the engraving which is reproduced are the representation of a non-existent course of stone above the upper cornice and some incorrect or implausible details in the representation of the brickwork.



The exposed faces of both the main and upper arches lean outward at their springings at the same angle as the piers from which they rise. There is a marked difference, however, between the outward displacements of their crowns, and this difference is both greater than and of opposite sense to the small one which would result merely from the greater rise of the upper arches. The difference corresponds to a progressive increase in the width of the exposed soffit of each upper arch as it rises, the main arches being of uniform width throughout. Thus, the crowns of the upper arches are displaced outward some 35 cm. less than would be expected as a result of the outward leans at the springings, while the crowns of the main arches are, on the contrary, displaced some 15 cm. further than would be expected. The inner faces of the tympana are, of necessity, displaced outward at their heads to the same extent as the crowns of the main arches. Instead of a gradual warping outward of these faces toward the center, though, the slope is almost uniform for most of their height throughout their length and there is a conspicuous adjustment in the last 3 m. The outer faces, if some local slight irregularities are ignored, have a uniform slope throughout with no adjustment near the head and, as noted by Underwood and Hawkins, this slope is much less than that of the inner faces. As the section shows, it is very similar to that of an imaginary plane drawn through points on the face of either upper arch at its springings and its crown.

The comprehensive study of the sequences of construction and reconstruction showed, at an early stage, that the present forms of all main elements of the structure could be best interpreted as distortions of forms initially set out with all unengaged upright faces vertical and with the profiles of all arches semicircular (with one relatively minor exception where this was impracticable).<sup>6</sup> The distortions clearly resulted from the large thrusts generated by the dome and the principal arches and semidomes. In magnitude they are now much greater than the recoverable elastic distortions inseparable from the bearing of load by any structural member. In part they could be attributed to plastic distortions in the slowly setting mortar used in large quantities in the upper parts of the building. To this extent they would clearly be dependent on the interval between construction and the time when a particular load became effective. Even bearing in mind the known speed of the initial construction and the references by Procopius<sup>7</sup> to some of the difficulties that ensued, it was evident that major distortions such as the outward leans of the main piers could not be accounted for solely by such plastic distortions. Tensile cracking accompanied by marked separations or shearing dislocations must also have played a part. The inevitable progressive increase in these separations and dislocations, accelerated from time to time by earthquakes, would be the main contributory factor to the successive collapses of the east and west arches and the dome.

<sup>6</sup> Rowland J. Mainstone, "The Structure of the Church of St. Sophia, Istanbul," *Transactions of the Newcomen Society*, XXXVIII (1965-66), 23-49.

<sup>7</sup> *De aedificiis*, VII (Loeb ed.), 28-31.

Confirmation that this interpretation was correct was initially provided by the remarkable consistency with which the distortions, so derived, conformed to those that would be expected on the basis of the already firmly established structural history. One example, directly relevant to the present discussion of the tympana, must suffice. Attention has been drawn to the greater outward displacement of the crowns of the main arches framing the tympana as compared with that which would be expected if the faces of these arches were inclined throughout at the same angle as the piers from which they rise. Other measurements show that this further outward movement was a consequence of an outward horizontal bending of each arch and that it is accompanied, in the vertical plane of the presumed semicircular setting-out curve, by a marked depression of the crown and outward rotation of the haunches. This rather complex three-dimensional movement, involving also some twisting of the cross sections, is precisely what would be expected to result from the dual structural role of the arch and the movements of its supports under the action of its own and other thrusts. It is called upon not only to carry the vertical weights of the structure above to the main piers but also, by virtue of its considerable transverse width, to span horizontally in transmitting to the main buttresses the horizontal thrusts of the dome that act to north or south. Quantitatively, moreover, the movements are in all respects consistent with the arches being, like the main piers, part of the original construction. They may be contrasted with the present distortions of the surviving sixth-century segments of the dome cornice immediately above. These segments are known to have been reconstructed in 558–63<sup>8</sup> and, though they do show some evidence of subsequent relative displacement of the individual marble blocks, both the horizontal bends and the depressions over the crowns of the arches are much less than those of the arches themselves.

Any other element of the main structure whose present distortions are similarly inconsistent with those of elements that were undoubtedly original was also likely to have been reconstructed either wholly or in part. Thus, as first pointed out by Conant,<sup>9</sup> the upper arches above the tympana must have been partly reconstructed, their exposed faces being brought forward progressively as they rise by amounts corresponding to the progressive increases in the widths of exposed soffits. This reconstruction must have immediately preceded that of the dome cornice just referred to. If the exposed faces were then made approximately vertical again, their present mean outward inclinations should give good indications of the extents of the outward leans of the main piers to north and south subsequent to the reconstruction. On this basis, about 60 per cent of the present total movement occurred up to 558 and the remaining 40 per cent subsequently.<sup>10</sup>

<sup>8</sup> William Emerson and Robert L. Van Nice, "Haghia Sophia, Istanbul: Preliminary Report of a Recent Examination of the Structure," *American Journal of Archaeology*, XLVII, No. 4 (1943), 403–436, esp. 423–36.

<sup>9</sup> *Op. cit.*, 75.

<sup>10</sup> This and similar estimates have been rounded off, for the purpose of the present discussion, in terms of the degree of reliance which it is thought can be placed upon them. The basic measurements have been checked to a high degree of accuracy and most estimates have been arrived at indepen-

If the same argument could be applied directly to the tympana, it could be concluded, from the similarity between the present inclinations of their outer faces and those of the inner faces of the upper arches, that they also must have been constructed at about the same time. This, however, would fail to explain the noticeable inward bends at the level of the upper cornice (which, though less than those of the lower cornice, cannot be ignored). It would also lead to the improbable conclusion that the columns of the arcades below must have been rectified much more recently since most of them are still much more nearly vertical.

Greater care is clearly called for in seeking the right interpretation of the evidence here. Both the tympana and the arcades are merely infillings of the main structure. They must fit the openings which they fill and must, in any reconstruction, have been adapted to any existing distortions of these openings. Some, at least, of the present inclinations, for instance, must be due partly to these adaptations, and the proportion which can be attributed to subsequent distortion must be somewhat indeterminate because of the options open to whoever was responsible for the reconstruction. Nevertheless, it is possibly correct to assume that the columns of the arcades were set vertically when moved to their present positions and that the outer faces of the tympana were rebuilt approximately vertically in their central portions. It is also reasonable to assume that the reconstructed lengths of the upper cornices and of the bases of the tympana were initially straight. It must then be remembered that, after construction, both the tympana and the arcades, as infillings, will have been subject to much more complex patterns of loading than the main elements of the structure.

If all the probable indications of distortion in the present forms of both tympana and arcades are considered together, they are much more consistent with the assumption that both were reconstructed at the same time. Further backward inclinations of the main piers after the reconstruction would inevitably carry the tympana back to the same extent where they are in contact with the main arches, but there would be no such direct action on the columns of the arcades. These, above the capitals, and the lower central portions of the tympana would be acted upon more directly by the gallery vaults thrusting inward toward the nave. The inclinations of the columns and the horizontal bends of the upper cornice, as well as of the tympana and spandrels of the arcades immediately above and below it, all indicate, if examined in detail, that this more direct action was sufficient largely to neutralize the indirect one of the backward movement of the piers, except in the area close to the piers. A better estimate of the extent to which the leans of the main piers increased after this reconstruction is given, therefore, either by correcting the present inclinations of the outer faces of the tympana to allow for the bends at the level of the upper cornice or by averaging the present outward inclination of

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dently from several different sets of measurements. Nevertheless, certain possibilities of error are inherent in the allowances that must be made for probably built-in irregularities and for the variable thicknesses of stucco etc. where the working masonry is inaccessible.

both tympana and arcades over their full height. On this basis, the increase has been probably not more than 30 per cent of the present total. This figure, in relation to the 40 per cent estimated as having occurred after 558, suggests that the reconstruction was undertaken well after that of 558–63, though it must obviously have been before the initiation of the post-iconoclastic scheme of mosaic decoration.

#### FIRST SERIES OF TESTS: JUNE 1966

Close inspections, in June 1966, of the main piers and buttresses, particularly in the spaces above the gallery roof where the working masonry can be studied with little difficulty, further confirmed the validity of the general approach to the interpretation of the precise present geometry of the forms that has just been outlined.

A direct independent test of the conclusions relating to the tympana and arcades was, nevertheless, considered desirable, but was more difficult because here none of the working masonry could be inspected without laboriously uncovering it first. As a preliminary to a possible more extensive exploration, one very limited test was proposed and undertaken just before my departure from Istanbul. This was the cutting of a narrow chase in the stucco to expose the brickwork immediately above the upper cornice along the length of the south tympanum. A similar chase was cut on the north side, but this had to be interrupted where gaps in the wooden railing alongside three of the niches would have made it too conspicuous. It was intended primarily to show the aggregate width of open cracks between the main piers. It could be assumed that as the piers inclined further to north and south they would also incline further to east and west and that the latter movements would be a fairly constant proportion of the former. The movements to east and west would, of course, increase the gaps between the piers that are filled by the tympana. Since the present total increases in the gaps are about 30 cm., the increases since 558, for instance, could be assumed to have been about 12 cm. The elasticity of the brickwork could be ignored, since it was unlikely even to have accommodated the full drying shrinkage of the newly constructed tympana, and the aggregate crack widths could thus be taken as fairly direct measures of the actual increases in the gaps.

Cracks totalling 8.8 cm. were, in fact, found at the foot of the south tympanum between the piers and there were two further cracks totalling 2.2 cm. slightly further west. Within the limits of accuracy to be expected here the previous conclusions were, therefore, confirmed. Paradoxically, however, a first inspection showed no signs of the expected joins between the original brickwork and the reconstruction. Nor were any seen in the more limited areas exposed at the north, though the extent of the cracking there was generally similar.

Subsequently Van Nice made two small test holes at the eastern extremities of the barrel vaults behind the tympana. On the east or west face of each main pier is a pilaster which receives the ends of the arcade. It is wider, at

gallery level, than the arcade itself, and the excess width is terminated just above the upper cornice (fig. 1). The openings were made immediately above these truncated pilasters and the only significant observation was that of a completely unbonded join between the brickwork of the pier and that of the springing of the barrel vault at the southeast.

#### SECOND SERIES OF TESTS: SEPTEMBER 1967

Re-examination, in 1967, of the chases cut at the feet of the tympana likewise failed at first to disclose the joins in construction. It was clear, though, that a possible reason for this was the minimal width of the chases and the damage done to the original surfaces of the bricks and mortar in removing the very hard cement stucco. Since it was desired to restrict any further cutting to what was most usefully revealing, attention was directed next to the cornices. It was noted that almost the entire length between the piers could have been dismantled with ease at the north. At the south, however, a block firmly embedded in the pier projected beyond it for a considerable distance at each end. At the southwest, moreover, this block had a chase cut in its top surface, obviously to receive a cramp, and this chase was now about 4 cm. forward of its other half on the adjacent block (F on folding plate, and fig. 7). The insertion of the cramp, intended to halt the separation of the piers, was obviously a repair before the reconstruction, and the misalignment of the chases now indicated equally clearly that the block to the east had been reset. Other cramps, still in place across this joint and across the joint almost in line with the edge of the northwest pier (fig. 5) and each set partly behind the face of the brickwork, must have been inserted in the reconstruction. The most likely locations of the construction joins seemed, therefore, to be almost in line with the edges of the piers at the north and somewhere nearer to the ends of the embedded blocks of the cornice at the south.

Permission was sought and readily granted to extend the previous narrow openings in these positions. Proceeding with care to hold damage to the brickwork to a minimum, the openings were enlarged to varying extents to disclose, in all cases, the expected joins (folding plate and figs. 5, 6, 7—the joins being marked by broken lines in these figures and in figs. 2, 8, 9). On first inspection there was no appreciable separation at any join, but its presence was unmistakably betrayed in several ways:

- 1) The regular coursing of the brickwork was interrupted to a greater or lesser degree. This interruption was most noticeable at the northwest, where the bottom two courses of the reconstruction corresponded to three courses of the original.
- 2) The pointing of the original brickwork was, like that of most sixth-century brickwork elsewhere in the building, finished to a concave profile leaving the full width of each brick exposed. The pointing of the reconstruction, on the other hand, was finished almost flush with the bricks and, by overlapping slightly their rounded edges, tended to diminish their apparent width and to exaggerate that of the joints.

3) The mortar used in the reconstruction differed also from the characteristic, almost white, sixth-century mortar. It was definitely pinkish, due to the incorporation of brick dust, but less pink than that used in the tenth-century reconstruction of the dome. This pinkish mortar had previously been noted by Van Nice at a higher level on the exterior of the south tympanum when some areas had been exposed by falls of stucco.

Careful probing in the joins with a fine tool showed that each contained, and was clearly distinguishable by, a fine black deposit that was not found where cracks occurred within previously continuous brickwork. The joins also differed from hair cracks in that, where original bricks had been cut in the trimming that preceded the rebuilding, no matching half was to be found on the other side of the join. On this side all brick ends, whether finished or cut, were mortared.

At the south it was possible to extend both openings sufficiently to follow the joins into the shallow niches. As expected, the original brickwork had been cut back obliquely at each end. More significant was the discovery that only in the reconstruction had the niches been formed from the start. In the two places where they now extend into the original brickwork they had been cut out of a mass that was originally of uniform thickness (figs. 6, 7).

All subsequent exploration was directed to establishing more completely the limits of the reconstruction and to finding further evidence of its probable date and of the probable original form of the tympana. The knowledge acquired on the upper cornice of the character of the reconstructed brickwork assisted greatly in identifying the joins where they were not immediately recognizable because of the small size of the initial test hole or because of damage to the original surfaces.

It was now apparent that the unbonded join observed by Van Nice in 1966 above the truncated pilaster attached to the southeast pier was part of the join between the original brickwork of the pier and the reconstruction. Some further uncovering above the corresponding pilaster at the northeast, and fresh holes above those at the southwest and northwest, laid bare the joins there also (D on folding plate, and fig. 2).

The most important feature noted in each opening was the unmistakable evidence of a fully bonded connection, originally, between the pier and the brickwork above the arcade. Ignoring a slight lateral dislocation at the northeast and northwest (accompanied by separations of about 2 to 3 cm.), this original bonded return was in line with the present springing of the barrel vault. In general, it had been cut back to the face of the pier alongside. One brick only, bonded into both the pier and the original brickwork above the arcade, projected over the stone block which terminated the pilaster at the southeast and northeast, but there was no indication that an arch or any other construction originally sprang from this.

No test was possible on the spandrels or soffits of the arcades below the upper cornice, but there was one indication that the arcades were reconstructed at the same time as the tympana. In place of the separations just referred to

above the northeast and northwest pilasters, a wide crack was found running into the original brickwork above the pier alongside the join at the southwest. At the southeast there was no such crack but there was clear evidence, in nineteenth-century stucco repairs, of a major crack running from the soffit of the barrel vault to the soffit of the arcade, roughly in line with the join in the cornice about 1.2 m. west of the pier. A continuous crack of this nature would not be expected if the arcades and tympana had not been reconstructed at the same time.

### THIRD SERIES OF TESTS: JULY 1968

To supplement the picture obtained from the tests above the truncated pilasters, four more smaller openings were made in 1968 at the outer ends of the barrel vaults (E on folding plate). Here the brickwork of the vaults belonged entirely to the reconstruction and no original bonded returns were found. In every case the finished face of the brickwork of the pier continued uninterrupted behind the springing of the vault. This did not necessarily indicate that the original vaults had a different form. They would almost certainly have been constructed after the piers, and normal practice would not demand a bond in such situations where relative movement might be anticipated but need not be regarded as serious.

In parallel with other investigations of the original form of the main piers at gallery level and of the dates of subsequent additions to them, attention was then transferred to the exterior of the tympana. Here the gallery roof gave easy access to the lower range of windows. One earlier test by Van Nice and Hawkins at the west end of the south tympanum had briefly exposed the crack shown in Salzenberg's engraving (fig. 4) and a closely related Fossati sketch, but it had shown a fully bonded connection between the tympanum and the main arch and no apparent intermediate break in construction between this and the late (probably Turkish) narrowing of the first window opening. It was now considered that joins between what remained of the original tympana and the reconstruction must exist here and in the three corresponding positions at the southeast, northeast, and northwest.

Permission to look for the joins having been granted, the stucco was removed first in the area of the previous test just above the roof at the southwest, then in the corresponding positions at the other three extremities, and, finally, at the level of the springing of the window arch at each extremity. Since this removal proved to be particularly revealing at the northwest and the stucco was relatively loose, a larger area was subsequently uncovered there (folding plate and figs. 8, 9).

The join just above the roof at the southwest, which had previously escaped notice, proved to have been obscured on the surface by a later patch. A few of the other joins were also not immediately apparent, but all were traced. In every case part of the original tympanum was found. Because it was fully bonded to and appeared to have been constructed simultaneously with the main arches up to the springings of the window arches, it was clearly original

and not part of the rebuilding that followed the partial dismantling during initial construction that is referred to by Procopius.<sup>11</sup> Here a normal bond became impossible, and the few bricks that remained of each window arch extended as one unit into the mass of the main arch. The pointing on their faces also extended into this mass, indicating that these window arches had been constructed first and the main arches then built up around them (fig. 9).

The original form was best displayed at the northwest. Here the finished (pointed) jamb and part of the finished soffit of one window opening had been left untouched, with the new work simply butted up against them (AA on folding plate, and fig. 8). Elsewhere the original jambs had been cut away to a varying extent. At the southeast this seemed to have been done deliberately to bond in the new work. The irregular joins at the southwest and northeast may, however, simply have followed the lines of earlier cracks.

In relation to the earlier conclusion that the greater verticality of the outer faces of the tympana, as compared with the inclinations of their inner faces and the main piers, denoted a rectification at the time of reconstruction, the direct evidence of rectification that was discovered was particularly interesting. Enough remained of the original outer faces to show that they did indeed incline outward to the same extent as the main piers. To avoid surface discontinuities of several centimeters at the joins it was necessary, therefore, to adjust the inclination of the new work locally to match that of the original or to trim the face of the original back alongside the join. The latter alternative was adopted at the northwest and southeast, where the trimming back of the original faces could be very clearly seen at the level of the window arches (fig. 9).

#### EXTENT AND DATE OF THE RECONSTRUCTION

The extent of the reconstruction of the upper cornice, the tympana, and the barrel vaults behind the tympana was well defined by these tests (folding plate), but no tests were possible on the faces or soffits of the arcades below the cornice, on the arches that carry the outer springings of the barrel vaults, or on the gallery vaults beyond these arches. In considering the full extent of the reconstruction it is necessary, therefore, to rely on less direct evidence.

The present alignments of the arcades, the distortions they have undergone at the ends, and the surface indications of underlying cracks all show that they also have been reconstructed, almost certainly at the same time as the tympana.<sup>12</sup> They would, in any case, have been cracked open to the same extent as the cornice and the bases of the tympana; so it would be surprising if the reconstructions had not been undertaken together.

<sup>11</sup> *Op. cit.*, 30–31.

<sup>12</sup> Measurements, available only after this paper was written, of the inclinations of all the columns provide more conclusive confirmation that the arcades were reconstructed at the same time as the tympana. At both north and south, these inclinations diminish progressively toward the center of the arcade as the inward thrusts of the gallery vaults increasingly neutralize the contrary pulls of the backward leaning piers. The inclinations of the columns nearest the centers average less than 30 per cent of the estimated increases in the pier tilts subsequent to the reconstruction of the tympana, whereas those of the columns nearest the piers average more than 80 per cent.



A fuller examination than has yet been possible of the precise forms of all the arches and vaults of the central bays of the gallery may indicate whether the reconstruction extended beyond the barrel vaults behind the tympana and, if so, how far, but a definite conclusion will be more difficult to reach here. One reason is the probable lesser degree of accuracy achieved in setting out these relatively minor elements. Another is the likelihood of local patching here rather than of complete reconstruction. Such patching has already been confirmed in the main domical vault over the northwest bay of the gallery.

Further evidence for the date of the reconstruction has been furnished by the observations on the character of the mortar and pointing and by C14 measurements on three specimens of wood. It points, like the precise present geometry of the forms, to a date well after the reconstruction of 558–63 but before the initiation of the post-iconoclastic scheme of mosaic decoration.

Both the mortar and the pointing of the reconstructed brickwork are, as has been noted, intermediate in character between those typical, elsewhere in the building, of the sixth and tenth centuries,<sup>13</sup> and they differ sufficiently from both the earlier and later types to indicate considerable changes in practice. Only one close parallel to both mortar and pointing has been found. This is in the reconstruction of the upper parts of the main structure of St. Irene which George<sup>14</sup> dates immediately after the earthquake of 740 and which cannot have been earlier than this. Both the mortar and the pointing closely resemble those of the reconstruction of the tympana. Similar pointing has also been found inside the present upper storey of the Treasury of St. Sophia and inside one of the towers of the land walls just north of the Silivri Gate. The Treasury cannot yet be dated independently, but the tower bears an inscription of Leo III and Constantine V and is, therefore, roughly contemporary with the reconstruction of St. Irene.

Three specimens of wood were dated from their C14 content by the University of Michigan.<sup>15</sup> One came from a rough length of timber built into a hole in the easternmost niche of the south tympanum, possibly to support scaffolding during the reconstruction. The second came from a rough beam spanning a small arch at the level of the upper cornice above the pair of columns that stands just behind the south gallery arcade. The third came from the stub of a tie above the east face of the impost block of the eastern column of this pair. Thus the first and second could, almost certainly, be associated with the reconstruction, while the third, if its age proved to be similar, probably was. The ages were estimated as  $1260 \pm 130$ ,  $1340 \pm 130$ , and  $1160 \pm 120$  respectively. Solely in terms of the possibilities of error inherent in the C14 counts, there is a two in three chance of the true ages of the specimens falling within the limits stated. If the limits are doubled there is still a one in twenty

<sup>13</sup> W. Emerson and R. L. Van Nice, *op. cit.*, 216–21, discuss and illustrate the principal characteristics of sixth- and tenth-century brickwork as seen in the stairways of the southeast buttress. Tenth-century brickwork is distinguished by slanted weathered pointing of the horizontal joints. The characteristics of the mortars of the joints themselves have been referred to above.

<sup>14</sup> Walter S. George, *The Church of Saint Eirene at Constantinople* (London, 1913), 69–71.

<sup>15</sup> Specimen nos. One=M-2209; Two=M-2210; Three=M-1942.

chance that the true ages will fall outside. Since the ages relate to the short periods of growth of the specimens as parts of the living cambiums of the trees from which they came, the dates of incorporation of the timbers in the structure will, of course, always be later, and may be substantially later, than those derived directly from them. Bearing this in mind, these latter dates—690, 610, and 790 with the same ranges of probable errors—are approximate termini post quem for the construction of those parts of the structure from which the specimens were taken. In relation to the probable errors, the differences between these dates are not very significant and there is certainly no indication that the third specimen came from an earlier phase of construction than did the other two. The mean of all three—700—is quite consistent with all three timbers having been set in place soon after 740. There is, however, about a one in four chance that the true age of the second specimen was 1420 or more, in which case it could mean that the timber was taken from the original construction and reused. The mean age of the other two would then make a rather later reconstruction most probable, and this possibility cannot, on any interpretation, be ruled out.

To reach a more definite conclusion it is necessary, in the absence of any explicit textual reference to the reconstruction, to consider such textual evidence as does exist and some further evidence bearing on this.

Accounts of the earthquake of 740 make no mention of St. Sophia. The first mention of damage after the collapse of 558 occurs in references to the earthquake of January 9, 869. The earliest reference speaks of damage in many places.<sup>16</sup> It adds that the Emperor had the damage repaired, but gives no further detail. Since the reconstruction of the tympana must have preceded work on the mosaics and cannot, therefore, have been completed much after 869, there is thus some textual authority for assigning it to 869 or immediately afterward and none for any likely alternative. This, in itself, is inconclusive, but there are two further reasons for preferring this date to 740 or some intermediate date.

The first is the siting of the inscription which ran in several lines across the upper parts of both tympana. Two fragments were uncovered by the Fossati and, apart from the fragment of the uppermost line at the south, these have been identified with an epigram which has been quoted and discussed by Mango in his preliminary study of the mosaics.<sup>17</sup> The epigram does not specifically refer to the tympana, though it has been suggested that the uppermost line at the south might have done. It does, however, commemorate a repair by the Emperor, and there is good reason for believing this to be the repair undertaken by Basil I in about 869. Not only the prominent placing of the inscription on the tympana but also the nature of the reference to the repair strongly suggest that the reconstruction of the tympana constituted a major part of it. The repair was said to have been necessary because the church "had

<sup>16</sup> *Vita Ignatii*, PG, 105, col. 549A.

<sup>17</sup> Cyril Mango, *Materials for the Study of the Mosaics of St. Sophia at Istanbul*, Dumbarton Oaks Studies, VIII (Washington, D.C., 1962), 63–66.

been 'suffering' or 'afflicted' by the effects of time and time had 'threatened' to destroy it,"<sup>18</sup> and these words would exactly describe the progressive cracking apart and distortion of the tympana and arcades which would inevitably have occurred from a very early date as a result of the progressive separations of the main piers and distortions of the main arches. The second is the fact that the shallow niches below the windows appear to have been introduced for the first time in the reconstruction. Since they so effectively frame the mosaic figures of the bishops, it seems probable that they were introduced for this purpose, which would preclude any date much before 869.

I therefore date the reconstruction very shortly after the earthquake of 869, leaving open, however, the possibility that it may have been planned and even commenced shortly before. This possibility cannot be excluded because, as has just been stated, the damage which led to its being undertaken would, in large measure, have been long standing and it is doubtful whether the brief textual references can be relied upon to distinguish between repairs undertaken only after the earthquake and repairs already in progress.

Nothing was found that could be associated with the partial rebuilding that is referred to by Procopius, and this was probably much less extensive.

#### ORIGINAL FORMS OF THE TYMPANA AND ARCADES

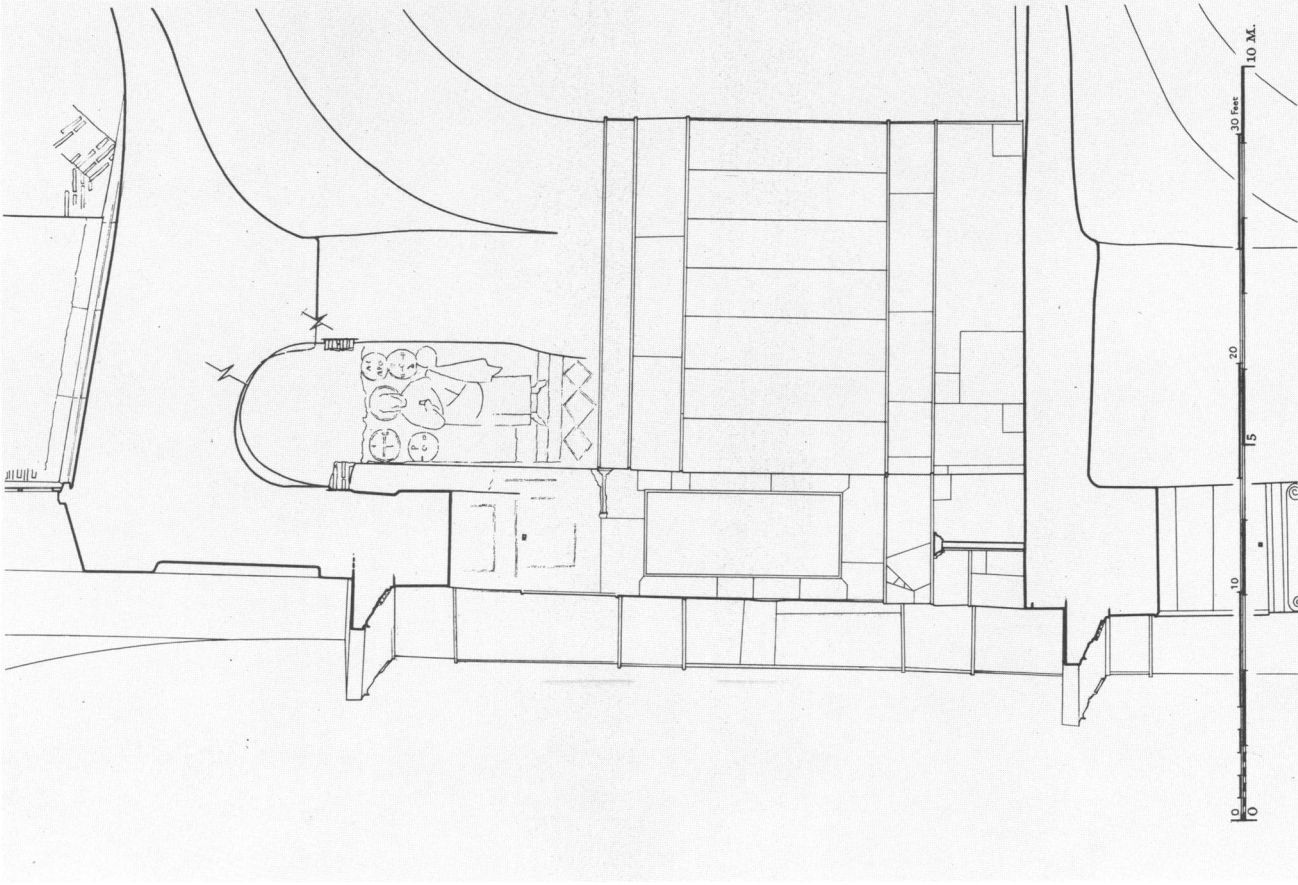
Enough evidence now exists to show that the original tympana and arcades were probably almost identical with the present ones except for the absence of the shallow niches below the lower ranges of windows. Above these windows, however, no detailed examination was possible, and it is highly unlikely that anything now remains from the original construction. One can only speculate, on the basis of the Silentiary's description,<sup>19</sup> that in place of the present groups of three windows there were single, larger windows resembling the main west window.

There is no indication that the pilasters which receive the ends of the arcades (fig. 1) ever carried anything to justify their present excess width. This excess appears always to have been abruptly terminated, as now, at the level of the upper cornice. It seems to be explicable only in terms of a change in the design when the main piers had already reached some height above the gallery floor but work had not yet started on the arcades. It has been tentatively suggested<sup>20</sup> that the intention may have been to make all the arcades at gallery level similar in design to those below, as was done at SS. Sergius and Bacchus.

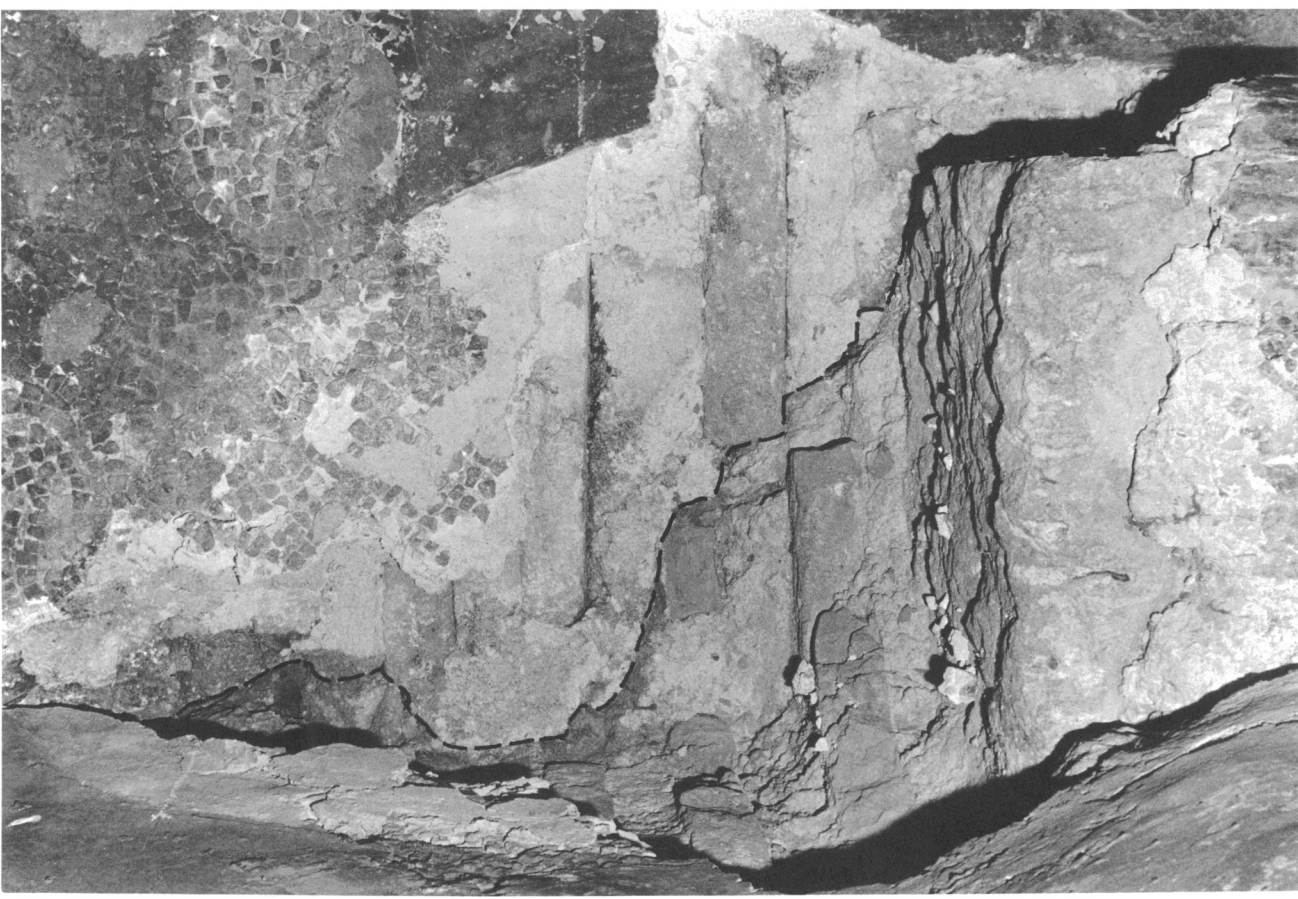
<sup>18</sup> *Ibid.*, 65.

<sup>19</sup> Paulus Silentiarius, *Descriptio Sanctae Sophiae*, line 536 (in P. Friedländer, *Johannes von Gaza und Paulus Silentiarius* [Leipzig-Berlin, 1912], 242), refers to eight windows in all. Assuming that there were, as now, seven in the lower range answering directly to the bays of the arcade below, this means that there can only have been one above. A possible form of this is illustrated in K. J. Conant, *op. cit.*, pl. xxxviii. The present groups of three windows referred to are those shown in the Salzenberg engraving (fig. 4) without the later narrowings of the openings.

<sup>20</sup> R. J. Mainstone, "Justinian's church of St. Sophia, Istanbul: Recent studies of its construction and first partial reconstruction," *Architectural History*, 12 (1969), 39-49.



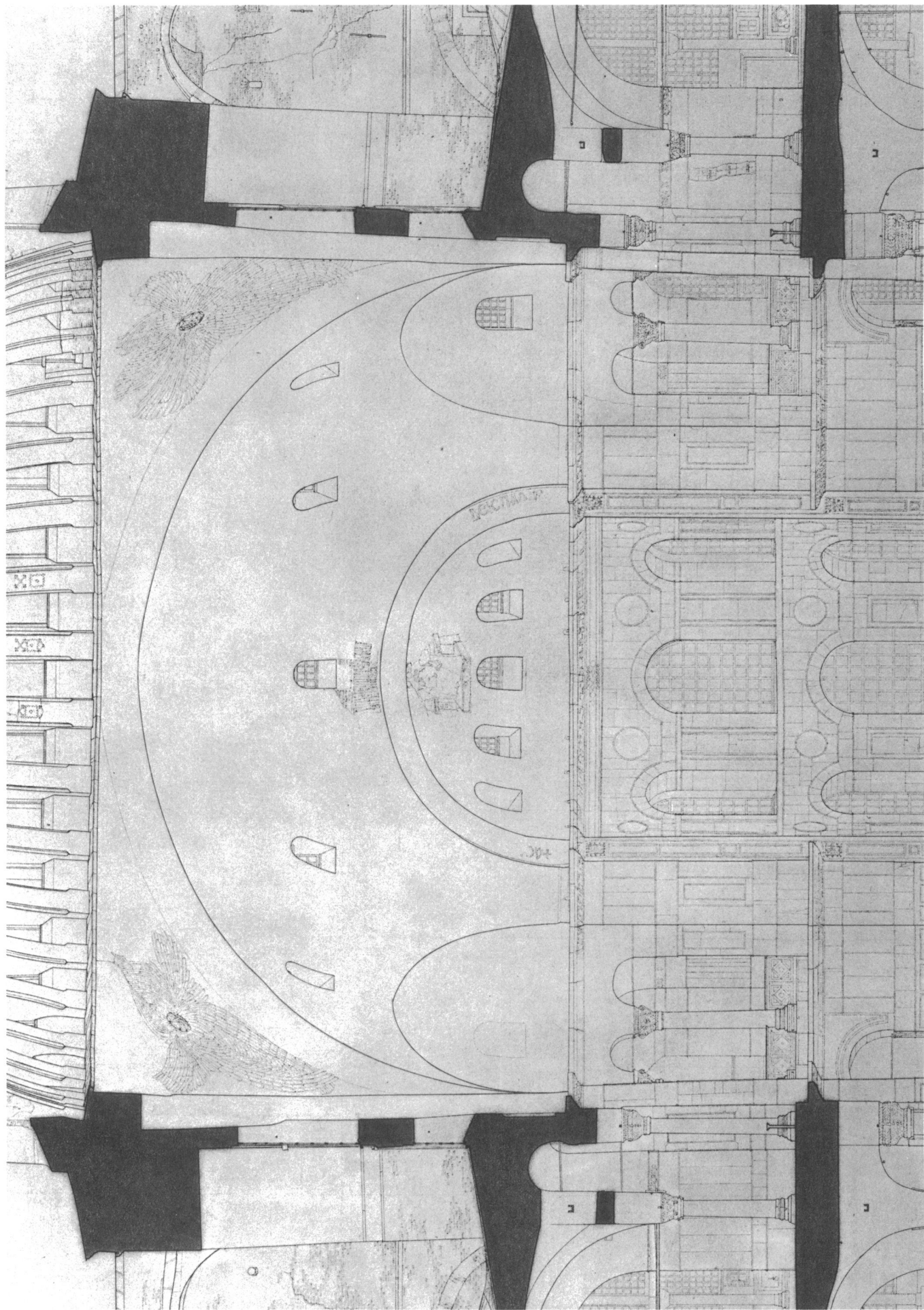
1. Alexander Mosaic and Northeast Pier and Pilaster at Gallery Level



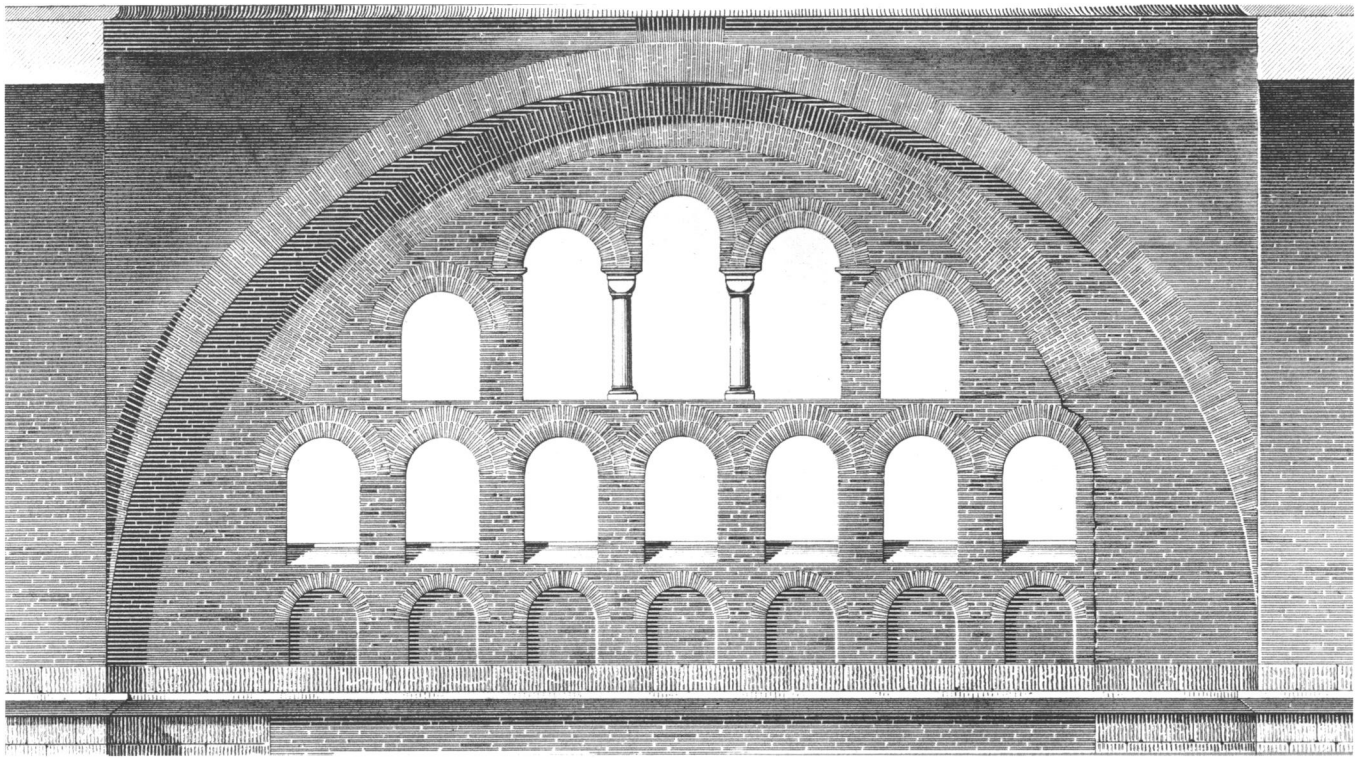
2. Springing of Barrel Vault above Northeast Truncated Pilaster.  
Detail, looking South

Istanbul, St. Sophia





3. Istanbul, St. Sophia. Transverse Section (1:200)

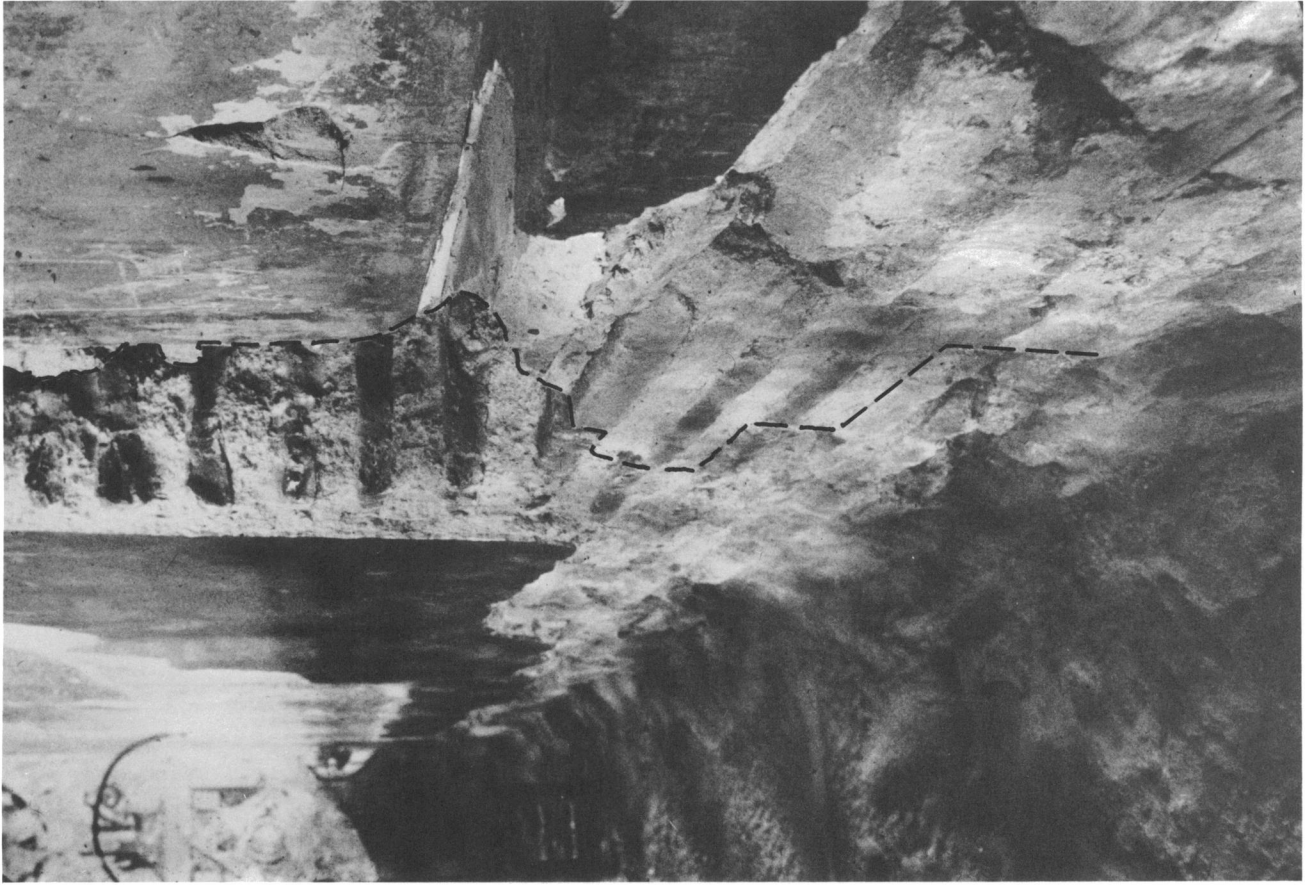


4. South Tympanum, Interior Elevation, according to Salzenberg



5. North Tympanum, West End. Detail of Test on Upper Cornice

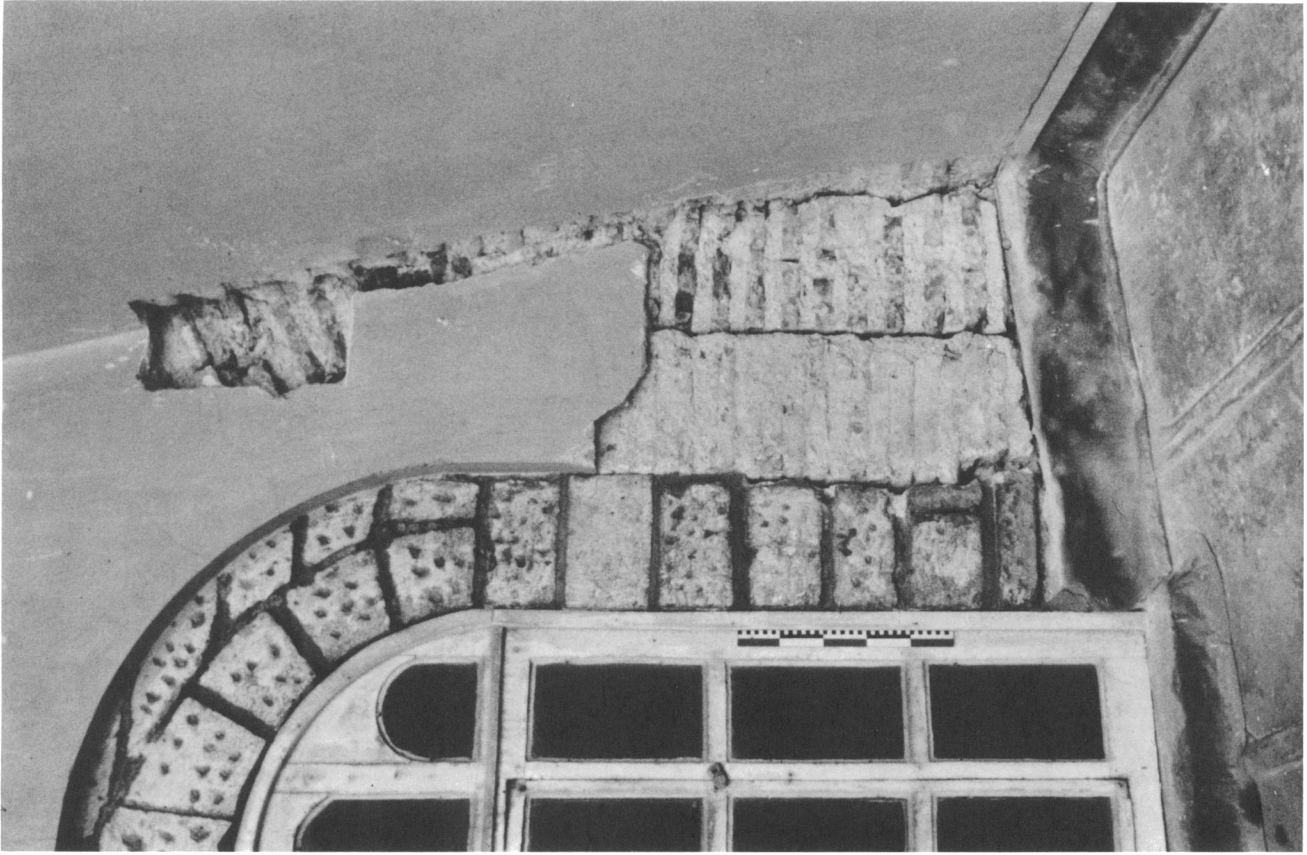




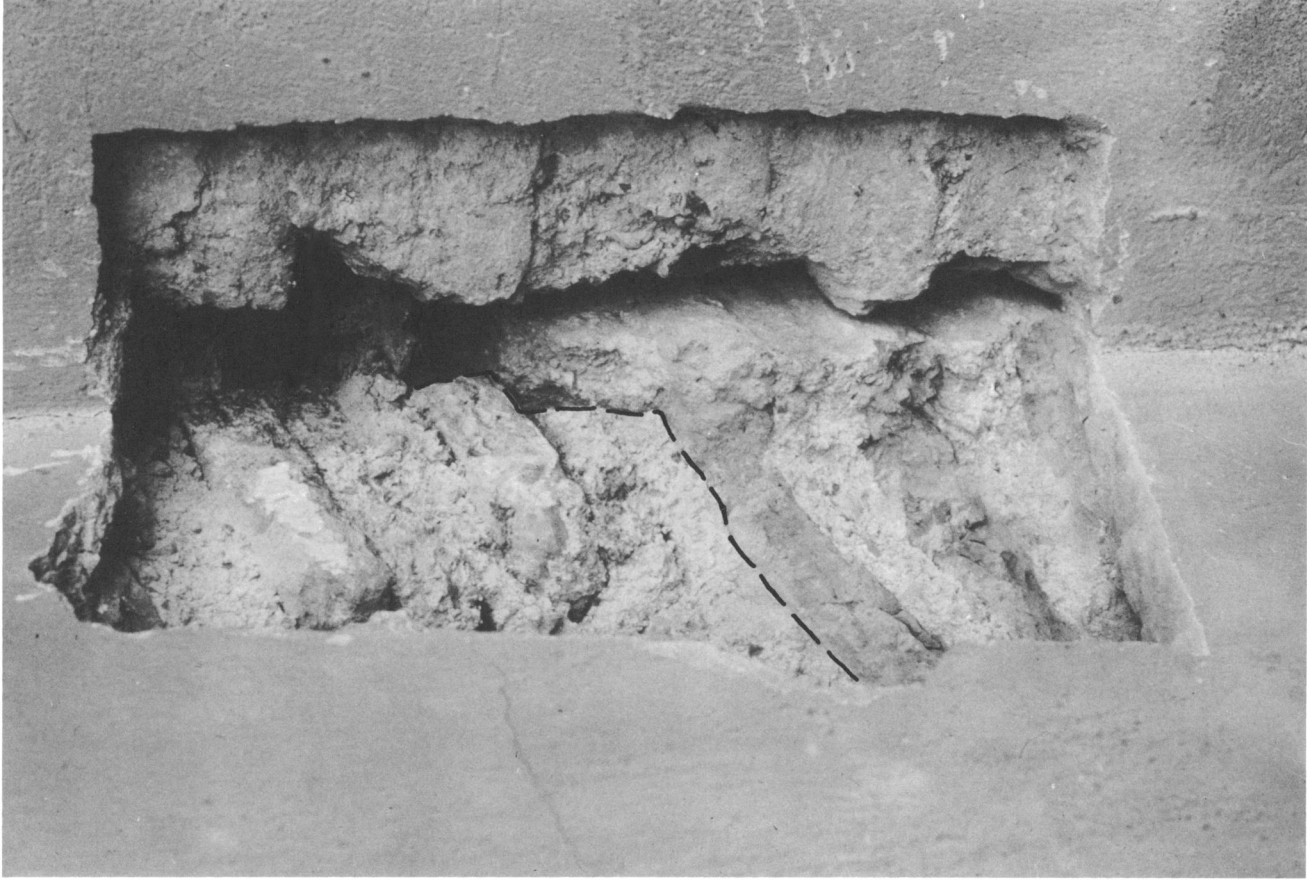
6. South Tympanum, Easternmost Niche



7. South Tympanum, Westernmost Niche

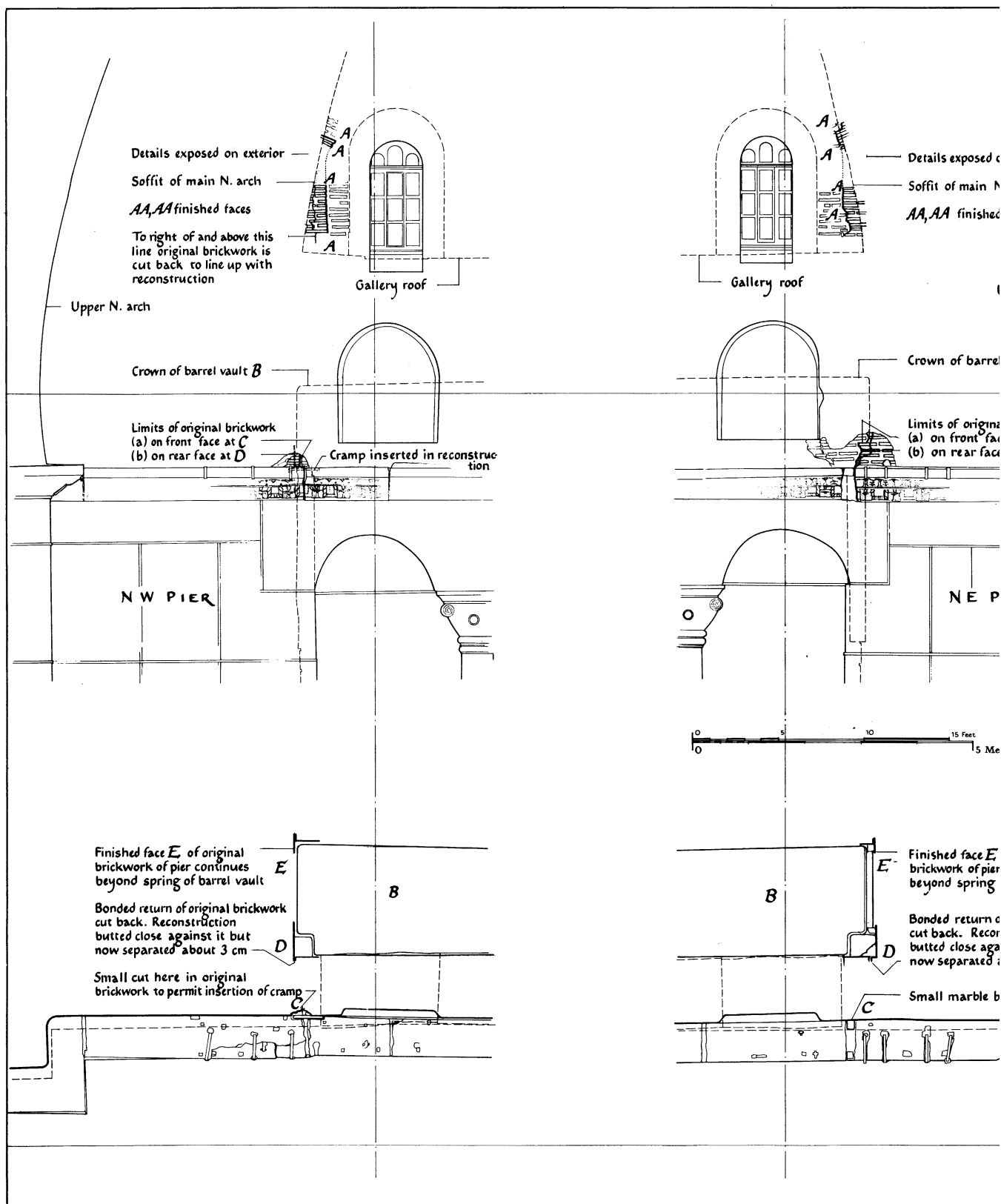


8. North Tympanum, West End, Exterior

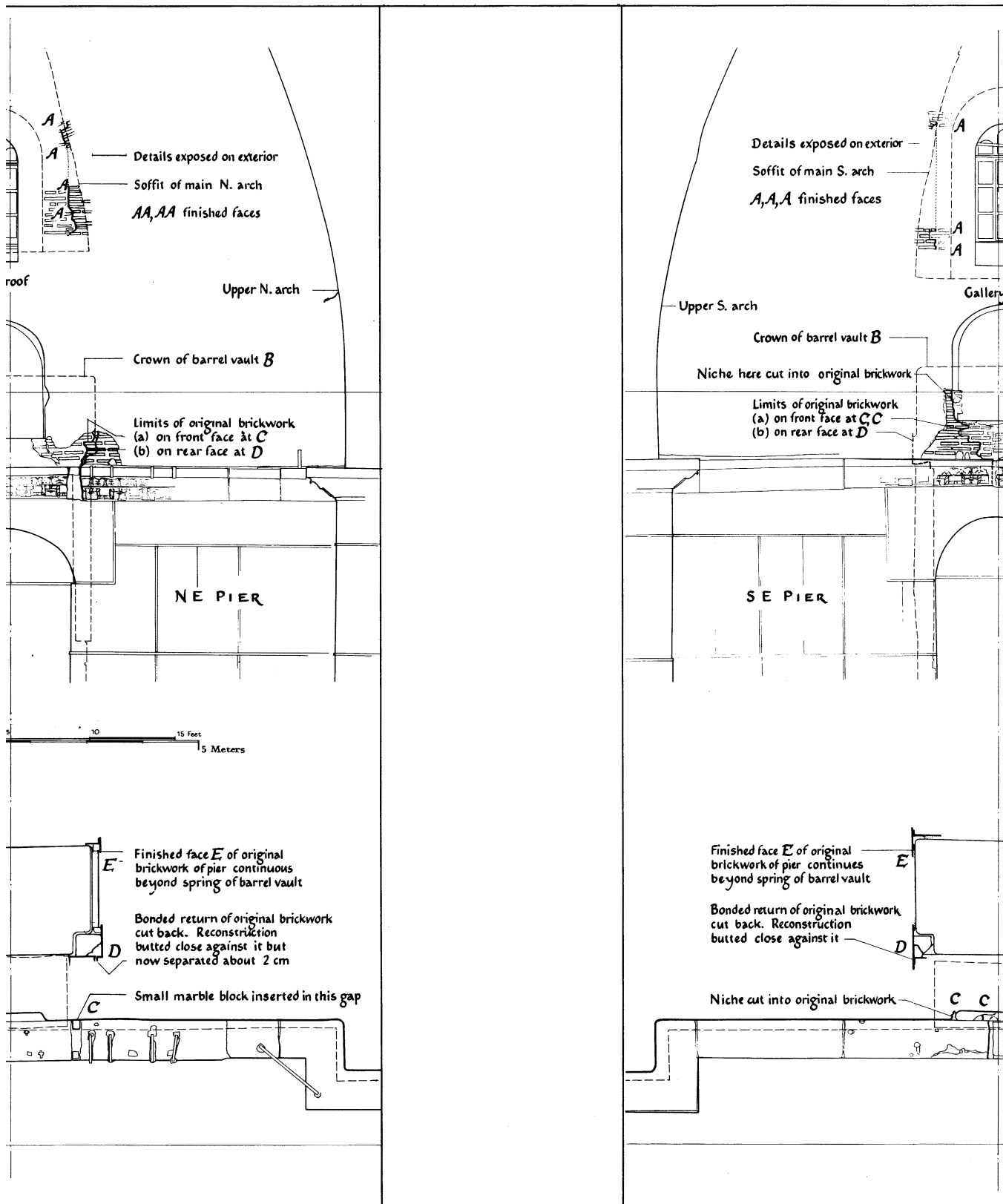


9. Upper Test seen in Figure 8. Oblique Detail

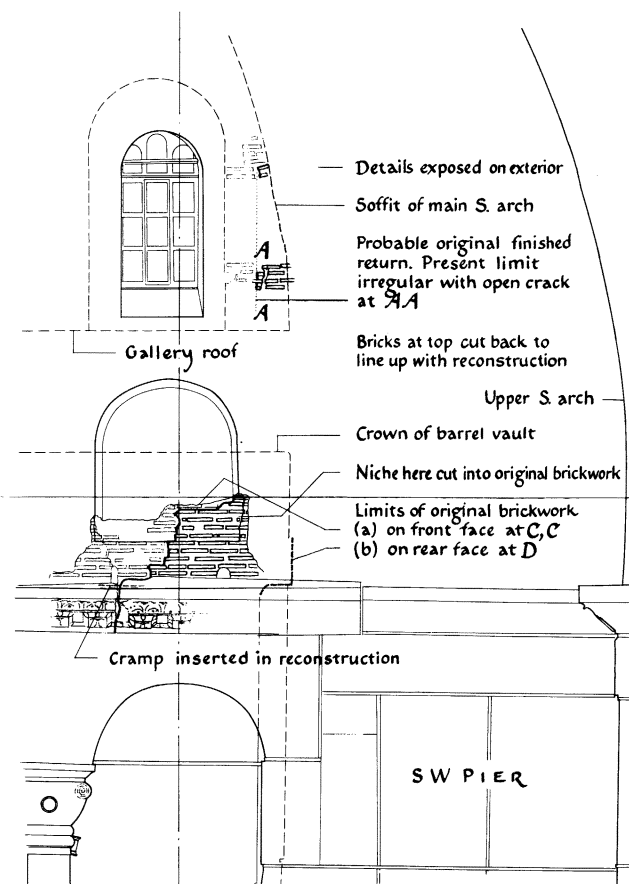
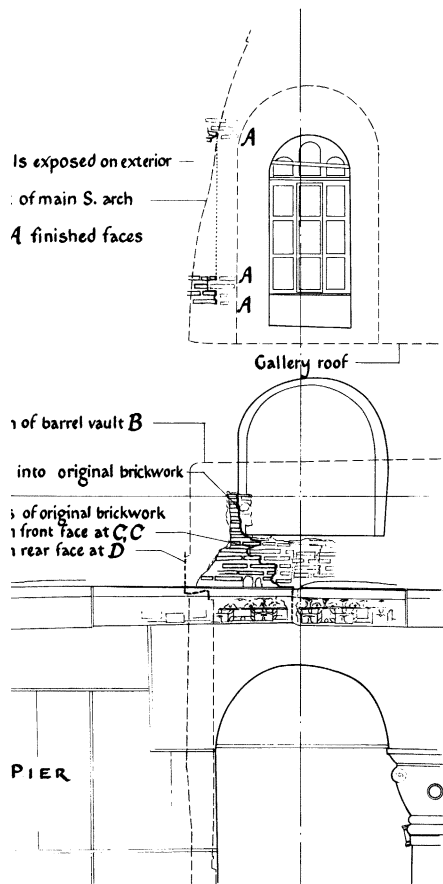




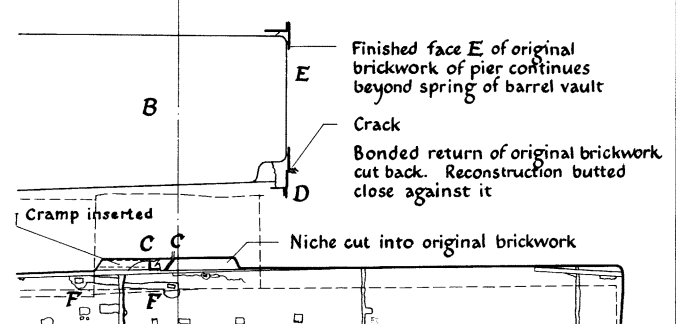
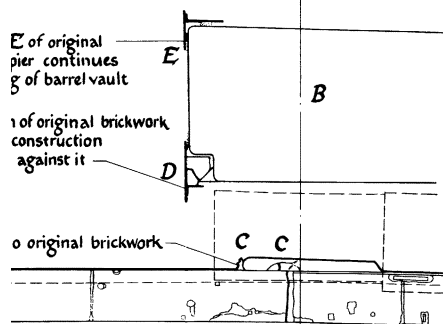
Istanbul, St. heavy line)  
depicted in Re



Istanbul, St. Sophia. Interior Elevations and Plans of Ends of Tympana, showing (in heaviest line) observed Limits of Reconstruction (1:100). Details exposed on Exterior are depicted in Reverse, as if seen from Interior. Plans are drawn just above Level of Upper Cornice.



0 5 10 15 Feet  
0 5 Meters



a, showing (in  
n Exterior are  
Upper Cornice.